The Efficacy of Coil Embolization at the Dissection Site of Ruptured Dissecting Vertebral Aneurysms

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Summary

Proximal occlusion of the parent artery has been widely used for treatment of vertebral dissecting ruptured aneurysms, but this does not always completely prevent re-rupture. In this series, the efficacy of occlusion at the dissection site using detachable coils was compared with proximal balloon occlusion.

Over a five year period, 25 patients suffering from subarachnoid hemorrhage with dissecting vertebral aneurysms were treated by endovascular surgery. The first three of these 25 patients were treated with proximal balloon occlusion of the parent artery. The remainder underwent platinum coil occlusion at the affected site as early as possible after the diagnosis.

In two of the three cases treated with proximal balloon occlusion, clipping or coating surgery were added because of progressive dissection. In all 22 cases of coil embolization, the intervention was successfully performed without complication. In one case with a dissection involving bilateral vertebral arteries, minor rebleeding from a contralateral dissection occurred after embolization. In the other 21 cases, rebleeding was not apparent (clinical follow-up: mean 24 months). Radiological findings showed complete occlusion of the dissection site and patency of the non affected artery (follow-up: mean ten months).

We conclude that detachable platinum coil embolization at the dissection site is more effective than proximal occlusion for treatment of ruptured vertebral dissecting aneurysms because of immediate cessation of blood flow to the dissection site. However, in cases with bilateral dissections or hypoplastic contralateral vertebral arteries, preceding bypass surgery or stent treatment to preserve the affected vertebral artery may be needed.

Introduction

For treatment of vertebral dissecting ruptured aneurysms, proximal occlusion of the parent artery with endovascular techniques or clipping has been widely used but these do not always completely prevent rerupture [1-6].

The efficacy of endovascular coil embolization at the dissection site was therefore com-

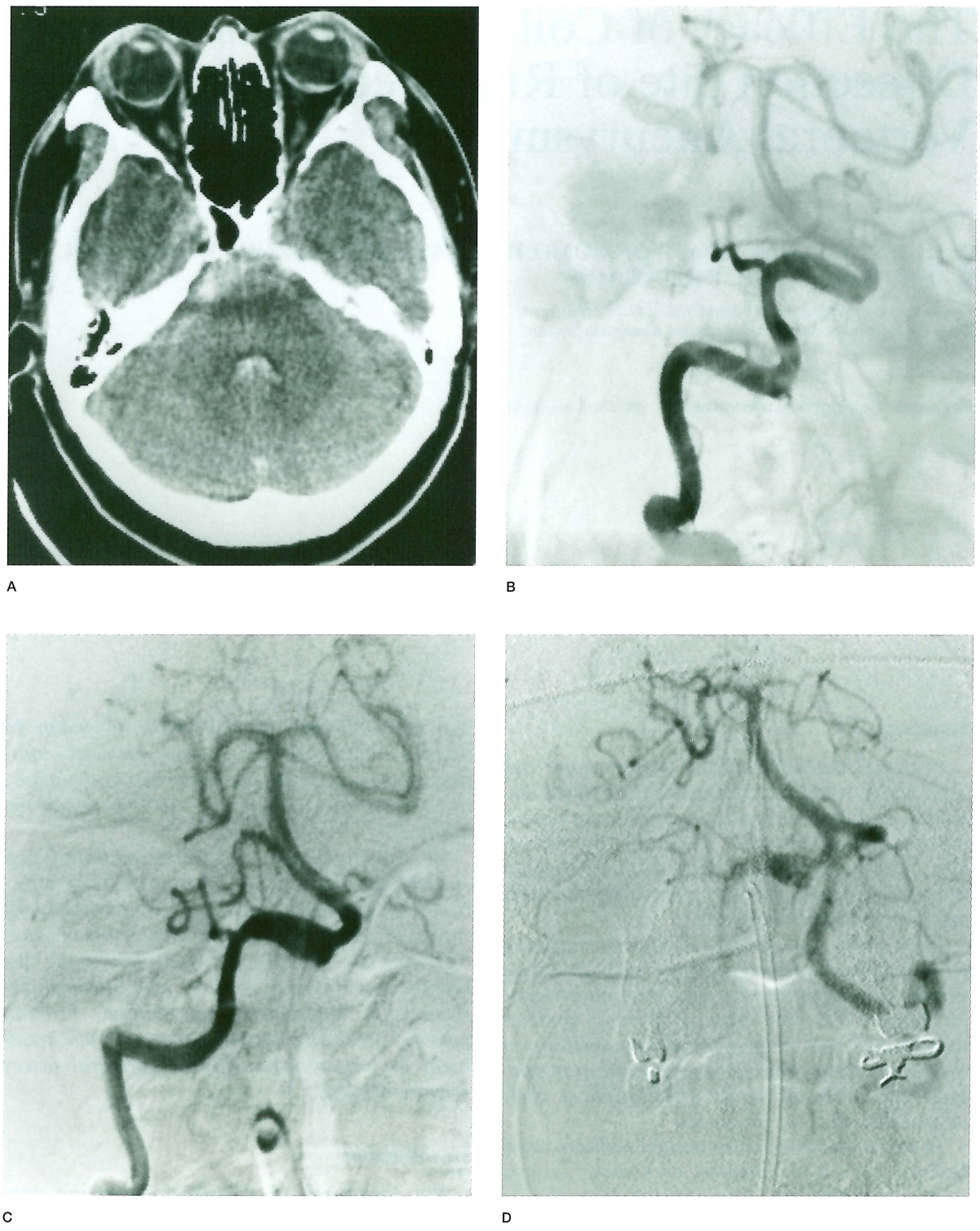


Figure 1 Case 1 A) Computed tomography showing a subarachnoid hemorrhage, located primarily in the pre-pontine cistern on the right side. B) Right vertebral angiogram on day 1, anteroposterior view, showing a dissecting aneurysm distal to the posterior inferior cerebellar artery origin. C) Follow-up right vertebral angiogram on day 16 showing progression of the dissection. D) Left vertebral angiogram after proximal balloon occlusion showing persistent blood flow to the right vertebral dissecting aneurysm.

pared with proximal balloon occlusion in a series of patients with comparatively long follow-up.

Material and Methods

Between 1996 April and 2000 December, 25 patients with ruptured vertebral dissecting aneurysms were treated with endovascular surgery in our institute. The patient's ages ranged from 28 to 62 years (mean: 52 years), the male/female ratio being 20: 5 (table 1). Pre-embolization neurological function was evaluated using the Hunt and Kosnik grading system and outcome with the Glasgow Outcome Scale (GOS). The first three patients were treated with proximal balloon occlusion of the affected parent vertebral artery. The remainder (cases 4-25) were treated with platinum coils using an endovascular technique to occlude the affected sites as early as possible after the diagnosis. In six of these (cases 3, 4, 6, 8, 18 and 21) involving dominant vertebral arteries, balloon test occlusion preceded the embolization.

Aneurysm location (table 1)

In 16 cases, the right side was affected, in 8 the left, and the remaining one (case 16) was bilateral. Nineteen were located distal to the origin of the posterior inferior cerebellar artery (PICA). Only 2 (cases 9, 13) were proximal and two (cases 17 and 22) included PICA involvement. In the other two (cases 7 and 20), the PICA was not recognized. Dominant vertebral arteries were affected in 7 patients (cases 3, 4, 6, 8, 18, 19 and 21), and four (cases 7, 9, 17 and 20) were non-dominant. In 1 (cases 18), contralateral left vertebral arteries were hypoplastic, ending in the PICA. Case 16 had bilateral involvement. The other 13 had almost the same sizes of affected and contralateral arteries.

Balloon test occlusion

In six cases involving dominant vertebral arteries, balloon test occlusion preceded coil embolization. A 3-French silascon balloon catheter (Kaneka Medics Co., Kanagawa) was introduced into the vertebral artery via a 6-French catheter. A 6-French sheath was also placed in the contralateral femoral artery. This was used to introduce a 1. 8-French BALT magic microcatheter (Marincrot Medical Co. France) to infuse heparin continuously into the distal of the balloon through a 5.5-French catheter.

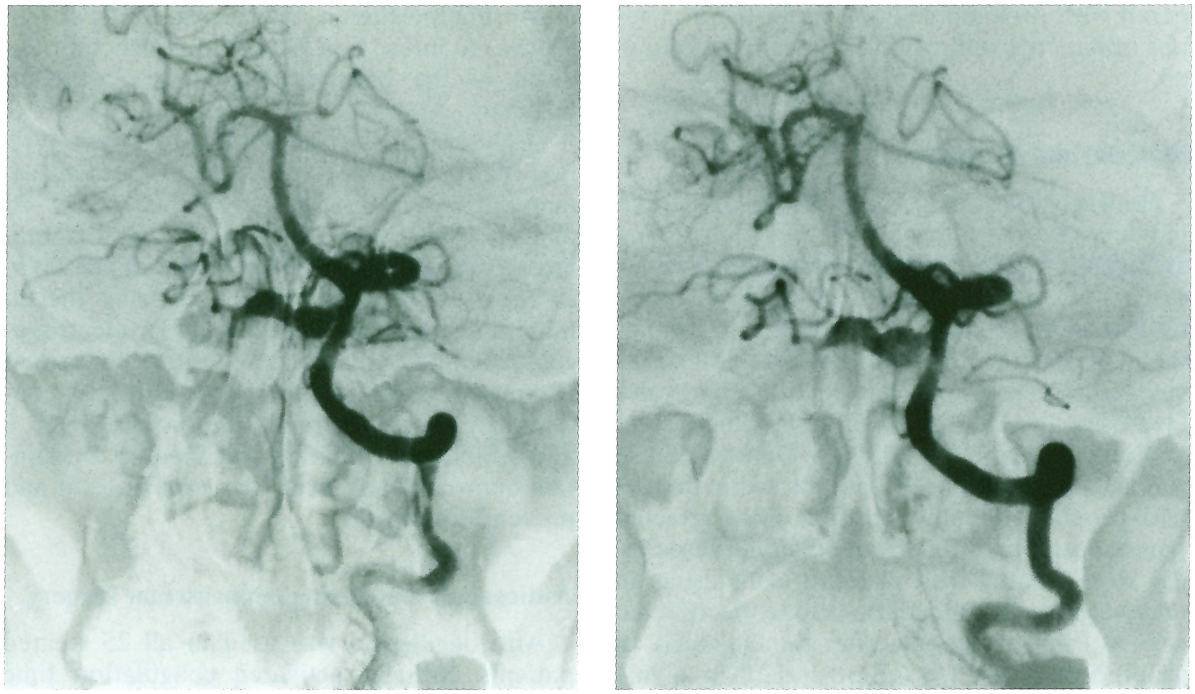
Occlusion of the vertebral artery was verified fluoroscopically with stasis of the contrast material injected through this latter. A 20 minute test balloon occlusion of the vertebral artery was carried out at the level of the body of the fifth cervical vertebra. During the 20 minute test balloon occlusion under electroencephalography (EEG) and auditory brainstem response (ABR) monitoring, heparin was continuously infused through the microcatheter, 6 and 5.5-French catheters and sheaths to maintain approximately twice the control level and prevent thrombosis.

Anticoagulation during endovascular surgery

Anticoagulation was used in all 25 treated patients. Initially, activated coagulation time (ACT) was assessed as a control through a 6-French sheath placed in the femoral artery. All the patients received a bolus injection of heparin (2000U) from the sheath immediately after the measurement of control ACT. During endovascular surgery, heparin was continuously infused through a 2.5 F Fas Tracker-18 two marker microcatheter (Boston Scientific Corp, Watertown, MA), a 6 F ENVOY catheter (Cordis Endovascular Systems, Miami Lakes, FL) and the sheath to maintain ACT from 1.5 to 2.0 times the control and prevent thrombosis[7].

Coil embolization at the affected site and Techniques

Initially a Transit soft tip guide wire (Boston Scientific Corp, Watertown, MA) was manipulated with the tip curved 45 degrees, shaped in line with the parent artery. The guide wire was advanced slowly preceding the microcatheter to a position just proximal to the dissection site with care taken not to enter the pseudo-lumen of the dissection. Thereafter, the curved guide guide wire was advanced slowly with rolling so as not to wander from the true lumen. Advancement of the microcatheter was performed until just proximal to the end of the dilated aneurysmal portion. The size of the first coil was selected as closely matching the aneurys-



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mal maximum diameter and sufficiently long to introduce for making a fixed basket. Before detachment of coils, repeated angiography at ten minute interval usually was performed to confirm fixation of the coils at the affected site. Since May 1998, Guido Guglielmi electrically detachable coils have become available in Japan, and these have subsequently been used instead of interlocking detachable coils (IDCs) because of their greater flexibility.

In all cases, endovascular coil embolization at the dissection site was performed as soon as possible to prevent rerupture (table 1). In all but four, endovascular surgery was carried out less than 4 days after the onset. The reason for the delayed treatment in cases 5 and 21 was that the dissection was not revealed by the first angiography (day 0), first becoming demonstrable on day 7 and after three months. In case 8, the first angiography on day 0 demonstrated a right vertebral artery dissecting aneurysm, but the contralateral left vertebral artery was not apparent until follow-up angiography on day 8. Repeat imaging on day 15 also demonstrated persistent good blood flow so that embolization of the right vertebral dissecting aneurysm could be performed. In case 23, initially clipping surgery underwent in other hos-

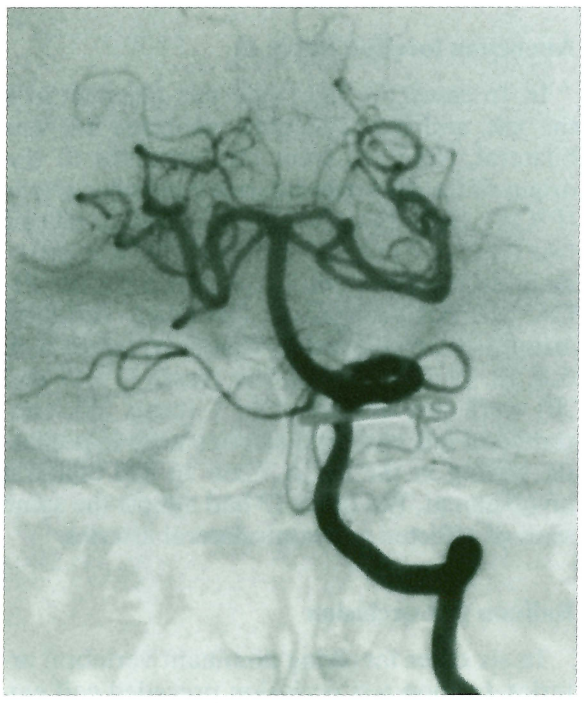

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Figure 2 Case 1 A) Left vertebral artery angiogram one month after the proximal balloon occlusion showing change in morphology. B) Follow-up left vertebral artery angiogram one month and three weeks after the treatment showing dilatation of the aneurysm. C) Left vertebral artery angiogram after clipping surgery to the distal portion of the dissection.

pital and dissecting aneurysm was defined by follow up angiography 6 months after the treatment, thereafter the patient was transported to our institute.

Follow-up angiography was performed one week and one month after the embolization. Magnetic resonance angiography (MRA) was performed at 3 months, 6 months and 1 year after the treatments, mainly in our out patient clinic.

Results

Re-rupture

Subsequent rupture occurred in 9 (cases 5, 7, 10, 13-17, 19) (36%) of the 25 patients, in all except one (case 17) within 24 hours of the first attack. In 4 (cases 5, 13, 14, 19) (44%), it occurred after less than 9 hours, in one (cases 14) immediately on arrival of the ambulance or on the way to hospital. Five (cases 5, 13, 14, 16, 17) (55%) of the 9 with rerupture suffered cardiopulmonary (cases 13, 17) or pulmonary arrest (cases 5, 14 and 16). All of the former fortunately recovered on resuscitation. However, in all 9 with rerupture, consiousness was disturbed from H&K grade I-II to III (case 7), IV (cases 5, 17 and 19) or V (5 cases).

Proximal balloon occlusion and complications (table 1)

No complications were experienced with the procedures for proximal balloon occclusion. However, in two of three cases, direct surgeries were added to the proximal occlusions. In case 1, clipping surgery was employed after the proximal balloon occlusion because of remarkable change of the morphology after the treatment. In case 2, coating surgery underwent after the treatment because of persistent blood flow to the dissecting aneurysm from contralateral VA. Right VIIth and VIIIth cranial nerve palsies occurred resulted in surgical injury.

Coil embolization at the affected site and complications (table 2)

In case 7, a saccular aneurysm of the left vertebral artery was found, which was embolized preceding treatment of the right vertebral dissecting aneurysm.

In case 16, involving the bilateral vertebral arteries on angiography on day 0, remarkable dilatation of the left dissecting aneurysm was evident in a follow-up angiogram on day 2, which was embolized to prevent rebleeding. No complications were experienced with the procedures for coil embolization. However, in case 16, rebleeding could not be prevented because of progression of the contralateral dissection, and the patient became comatose due to a brainstem infarction. In the other 21 cases, rebleeding was not apparent (clinical follow-up ranged from 1 week to 60 months: mean 24 months).

In case 17 with a dissection including the PICA, coil embolization was successfully performed. However, 1 day thereafter, infarction of the PICA territory occurred. Angiography performed immediately after the event showed patency of the PICA and recanalization of the vertebral artery and the cause of infarction could not be identified, although a thromboembolic event or ischemia due to the dissection were suspected. In the other 21 patients, the radiological findings confirmed complete occlusion of the dissection site and patency of the non affected artery (follow-up ranged from 1 week to 40 months: mean 10 months).

Hunt & Kosnik grade and GOS Scale (tables 1,2)

Thirteen cases were Hunt & Kosnik grade I-III. All except one (case 22 with severe vasospasm caused by subarachnoid hemorrhage) were treated with endovascular surgery esulting in good recovery. Fortunately in case 1, clipping surgery adding to the proximal balloon occlusion was in time to prevent re-rupture. Four were grade IV. Two (case 5 and 23) had good recovery, but the other two (cases 17 and 19) had cerebellar and brainstem infarction due to ischemia of the PICA territory resulted in MD and dead. The remaining 8 were grade V. All except one patients were treated with coil embolization and 4 achieved good recovery. One other suffered moderate disability, but the other 3 remained in a vegetative state and died.

Representative cases

Case 1 - A-57-year-old man suffered sudden onset of headache followed by nausea and vomiting, and was admitted to a local hospital.

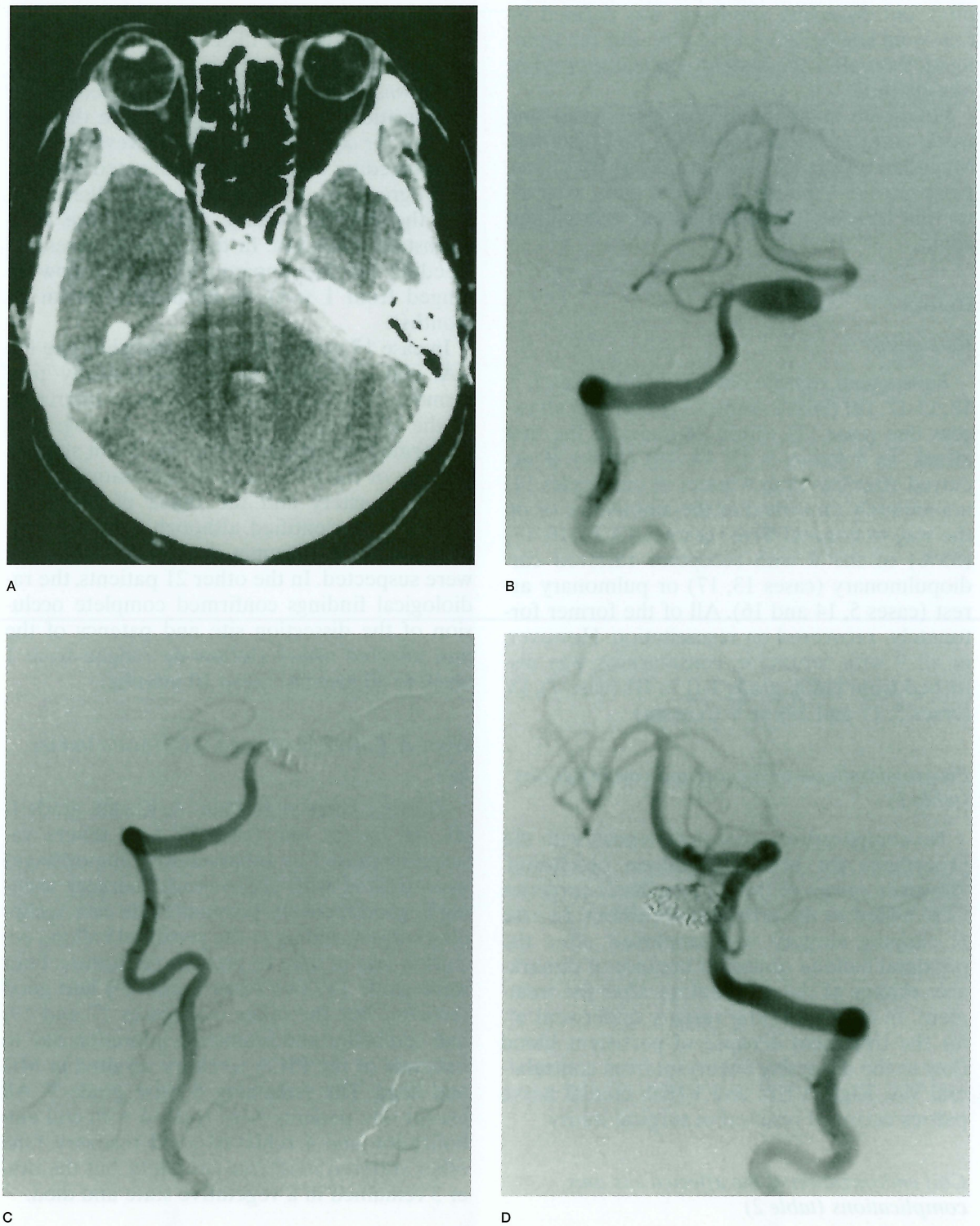
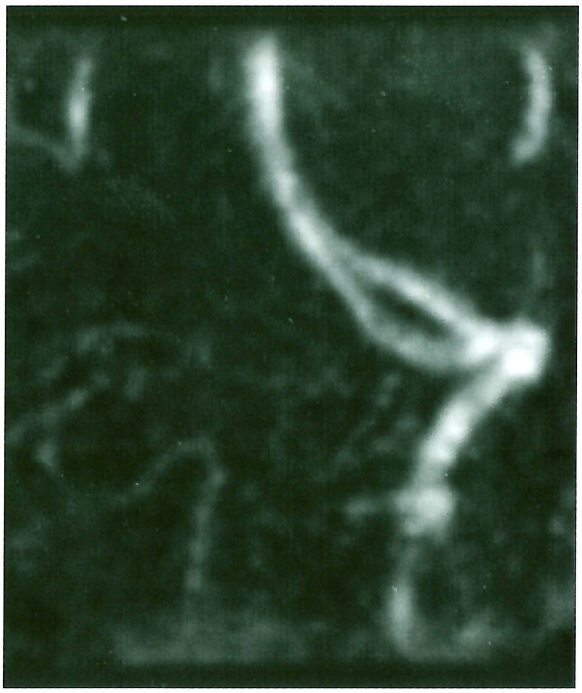


Figure 3 Case 24 A) Computed tomography showing a subarachnoid hemorrhage, located primarily in the pre-pontine cistern. B) Right vertebral angiogram on day 2, anteroposterior view, showing a dissecting aneurysm just distal to origin of the posterior inferior cerebellar artery. C) Right vertebral artery angiogram after coil embolization of the dissection site. D) Left vertebral artery angiogram after coil embolization of the dissection site. E) Follow-up magnetic resonance angiogram 6 months after the embolization showing complete occlusion of the affected site and preservation of the PICA.



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Computed tomography on admission showed a subarachnoid hemorrhage, especially located in the prepontine cistern of the right side (figure 1A). Angiography on day 1 showed a right VA dissecting aneurysm distal to the PICA origin (figure 1B). Follow-up angioghraphy on day 16 showed increase of the dissection (figure 1C), and was transported to our hospital by hericoptor. Proximal balloon occlusion of the right VA on day 34 was successfully performed (figure 1D). Left vertebral angiography revealed persistent of blood flow to the right VA dissecting aneurysm (figure 2A). Follow-up angiography one month after the embolization showed change of the morphology of the dissection (figure 2B), which was confirmed on follow-up angiography 1 month and 3 weeks after the treatment. (figure 2C), which was followed by trapping surgery (figure 2D).

Case 24 - A 56-year-old man presented with sudden onset of headache and vomiting followed by deterioration of consciousness. Neurological examination on admission showed Hunt and Kosnik grade II. During computed tomography, he became comatose and suffered severe cardiopulmonary disturbance. Computed tomography showed marked subarachnoid hemorrhage located in the pre-pontine cistern (figure 3A) and right vertebral angiography on day 2 demonstrated a VA dissecting aneurysm just distal to the PICA origin (figure 3B). Coil embolization of the right VA dissecting aneurysm was successfully performed on day 3 (figure 3C,D). Clinical course after embolization was uneventful and he could be discharged with no neurological deficit. Follow-up angiography 1 month after the treatment showed complete occlusion of the dissection site and patency of the right PICA, confirmed by follow-up MRA 6 months after the treatment. (figure 3E).

Discussion

Re-rupture

Aoki et al[1] first reported 2 cases of dissecting VA aneurysms re-rupturing in acute stages. Mizutani et al[8] (large series of 42 cases of ruptured dissecting VA aneurysms) described a high re-bleeding rate (30 cases: 71.4%), the majority with rupture within 24 hours (17 cases: 56.7%). A high mortality was associated with re-rupture (46.7%) compared to only 8.3% without re-rupture. In the present series, subsequent re-rupture occurred in 11 (44%) of 25, all except one occurring within 24 hours. Thus to prevent re-rupture, definitive treatment should be performed immediately after the diagnosis.

Aneurysm location

In this series, no side dominance was present, in contrast to the right side dominance reported earlier[2-9]. Mizutani et al[8] found 19 (61%) of 31 cases involving one VA to be located in the VA distal to the PICA origin (post-PICA type), 7 in the VA involving PICA origin (PICA-involved type), and only 5 (14%) in the VA proximal to the PICA origin (pre-PICA type) similar to our series where the respective values were 76%, 8% and 8%.

Regarding the size dominance of the affecting VA, there are few reports in the literature[8], the results being similar to ours (dominant VA affected in 7 cases, same size in 13, and non-dominant VA in 4).

Radiological findings

As shown here, a first angiogram may not always demonstrate a dissection, leading to mis-

Table 1 **Summary of details for the 25 patients with ruptured vertebral dissecting aneurysms treated with endovascular surgery**

Case NO.	Age(yrs) Sex	H&K grade	Pre-treatment re-bleeding	Location	treatment	Time (day)	Adding direct	surgery
1	57,M	II	none	rt VA PICA distal	PBO	31	+	
2	28, F	V	none	rt VA PICA distal	PBO	42	+	
3	58, F	II	none	lt VA PICA distal	PBO	23	-	
4	58, F	II	none	rt VA PICA distal	CE	4	-	
5	55, M	IV**	1	rt VA PICA distal	CE	7	-	
6	52, F	V	none	rt VA PICA distal	CE	1	-	
7	49, M	V	2	rt VA	CE	0	-	
8	58, M	II	none	rt VA PICA distal	CE	15	-	
9	52, F	III	none	rt VA PICA proximal	CE	0	-	
10	51, M	III	1	lt VA PICA distal	CE	0	-	
11	50, M	II	none	lt VA PICA distal	CE	1	-	
12	45, M	I	none	lt VA PICA distal	CE	0	-	
13	48, M	V**	1	rt VA PICA proximal	CE	0	-	
14	49, M	V**	1	lt VA PICA distal	CE	0	-	
15	55, M	V	1	rt VA PICA distal	CE	2	-	
16	41, M	V	1	bilateral VA PICA distal	CE	2	-	
17	50, M	IV*	1	rt VA PICA including	CE	2	-	
18	56,M	I	none	lt VA PICA distal	CE	0	-	
19	61, M	IV	1	rt VA PICA distal	CE	0	-	
20	62, M	II	none	rt VA	CE	1	-	
21	50, M	I	none	lt VA PICA distal	CE	90	-	
22	60, M	I	none	rt VA PICA distal	CE	3	-	
23	47, M	IV	1	lt VA PICA distal	CE	184	-	
24	56, M	V**	1	rt VA PICA distal	CE	3	-	
25	41, M	I	none	rt VA PICA including	CE	0	-	

*H&K: Hunt and Kosnik, VA: vertebral artery, PICA: posterior inferior cerebellar artery, rt: right, lt: left; PBO:proximal balloon occlusion, CE: coil embolization at the affected site, * Pulmonary arrest on arrival, **: Cardiopulmonary arrest on arrival*

diagnosis if repeat angiography is not performed. Nohjoh et al [10] also reported one case with a dissecting VA aneurysm which was not demonstrable one day after subarachnoid hemorrhage, but revealed by second angiography after 9 days. They emphasised that this type of aneurysm should be suspected when the cause of the subarachnoid hemorrhage is not clarified on the first angiogram. We also experienced such a case (patient 5). The finding of significant morphological change over several days strongly suggests the existence of a dissecting aneurysm.

Treatment

Proximal occlusion of the parent vertebral artery with endovascular techniques or clipping may be useful for the treatment of dissecting aneurysms [2,11-13]. However, it does not always completely prevent re-rupture, because blood flow may persist from the contralateral vertebral artery or the thyrocervical trunk [3,14]. Some cases with growth [3] or re-bleeding [1,2,4-6] after proximal occlusion of the parent artery have been reported. In this series also, two of three with proximal balloon occlusion developed

progressive dissection due to persistent blood flow from the contralateral vertebral artery. With a dissection site located in the vertebral artery proximal to the PICA division, proximal occlusion may be effective [15], since retrograde blood flow from the contralateral vertebral artery will supply the PICA beyond this. However, antegrade blood flow from the thyrocervical trunk may participate to preserve the vertebral artery flow.

Nakai et al [4] reported rebleeding in such a situation. This is important since the majority of vertebral artery dissections are of post-PICA or PICA involving type. Trapping surgery may be more reliable to prevent re-rupture, but this is invasive, and may cause the Wallenberg syndrome [6] and catastrophic events [8]. Detachable platinum coil embolization at the dissection site has been reported [16,17] and this may be more effective than proximal occlusion for ruptured vertebral dissecting aneurysms because of immediate cessation of the blood flow to the affected site. Coil embolization is a non-invasive technique, compared with trapping surgery, with the further advantage of allowing preceding occlusion testing.

With regared to technical assessment during coil placement, Graves VB et al [12] reported the utility of temporary proximal flow arrest using an undetachable balloon that can reduce the risk of distal emboli and difficulties of deploying coils in the arterial flow stream. On the other hand, Barr JD et al [13] reported that adequate selection of the first coil (33% to 50% larger diameter than the diameter of the parent artery) with anticoagulation removes the need for such flow arrest techniques to prevent distal emboli and inadvertent distal coil migration.

In this series also, without any flow arrest technique, embolic complications did not occur with continuous heparinization maintaining twice the control ACT during coil embolization.

Repeated angiography at ten minute intervals to confirm fixation of the coils at the affected site was usually performed. The reason for no use of flow arrest techniques is that inadvertent distal coil migration may occur with re-starting blood flow just after deflation of the proximal balloon.

Mahmood et al [18] reported that perforators can arise from vertebrobasilar arteries between approximately 14 mm proximal and 16 mm distal to the union. Special attention should be paid when a dissection is near this site. Before detachment of the coil, repeated tests with neurological and ABR examinations should be performed for the actual affected site.

Where bilateral dissection or a hypoplastic contralateral vertebral artery are encountered, preceding bypass surgery or stent treatment to preserve the affected vertebral artery [19,20] will be needed before detachable platinum coil embolization of the dissection site.

Table 2 **OutcomeA for the patients with ruptured vertebral dissecting aneurysms treated with endovascular surgery**

Case NO.	GOS	Follow-up ANG (after treatment)	Clinical follow-up period
1	GR	complete (1M)	10Y
2	GR	complete (9Y)	9Y
3	GR	complete (8Y)	8Y
4	GR	complete(39M)	46M
5	GR	complete(19M)	37M
6	D	complete (1W)	2W
7	VS	complete (2M)	28M
8	GR	complete (15M)	33M
9	GR	complete (30M)	30M
10	GR	complete (12M)	27M
11	GR	complete (1M)	24M
12	GR	complete (17M)	20M
13	MD	complete (1M)	14M
14	GR	complete (1M)	15M
15	GR	complete (13M)	13M
16	D	*complete (1W)	2W
17	D	incomplete (1D)	1W
18	GR	complete (1M)	5M
19	MD	complete (1M)	5M
20	GR	complete (1M)	3M
21	GR	complete (1M)	2M
22	D	-	1W
23	GR	complete (15M)	23M
24	GR	complete (6M)	12M
25	GR	complete (3M)	5M

GOS: Glasgow Outcome Scale,
GR: good recovery, MD: moderate disability,
VS: vegetative survival, D: dead,
ANG: angiography,
(D: days, M: months, W: weeks, Y: years,
**complete: treated left side dissection completely occluded.*

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